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librium. Let R =the reaction of the rod concentrated at G , its center of gravity; μ =coefficient of friction; W =weight of rod; β =inclination of plane to horizon; θ =required angle.

The reaction R at G is perpendicular to the plane, and is $R=W\cos\beta$; while $W\sin\beta$ is the pull down the plane. Now as friction acts opposite to the direction of motion, we get $W\sin\beta\sin\theta=\mu R$.

$$\therefore W\sin\beta\sin\theta=\mu W\cos\beta, \text{ or } \sin\theta=\mu\cot\beta; \theta=\sin^{-1}(\mu\cot\beta).$$

223. Proposed by G. B. M. ZERR, A. M., Ph. D., Philadelphia, Pa.

A sphere, radius $r=\frac{1}{3}$ inches, density $\delta=11.38$, falls from a height $h=500$ feet, into a lake depth $l=40$ feet. Find time of falling to surface of lake, time of falling from surface of lake to bottom, and total time of falling. Also the velocity at the bottom.

Solution by the PROPOSER.

Let $r=\frac{1}{3}$ inch $=\frac{1}{36}$ feet=radius of ball; $g=32.2$ =gravity; $e_2=g$ =weight of unit volume of water; δ =density of air=.001293; $e_1=g\delta$ =weight of unit volume of air; R_1v^2 =resistance of air; R_2v^2 =resistance of water; A =greatest sectional area of sphere $=\pi r^2$; k =a constant $=0.51$ for the sphere; m =mass of sphere $=\frac{1}{18}g$; v_1 =velocity at surface of lake; v_2 =velocity at bottom of lake. Then the equations of motion are

$$m \frac{dv}{dt} = mg - Rv^2 \dots (1), \quad mv \frac{dv}{dx} = mg - Rv^2 \dots (2).$$

From (1), $t = m \int \frac{dv}{mg - Rv^2}$. For the time, T , from rest to the surface of the lake, $R=R_1$, and the limits of v are 0 and v_1 .

$$\therefore T = \frac{1}{2} \sqrt{\frac{m}{gR_1}} \log \left[\frac{\sqrt{(mg) + \sqrt{(R_1)v_1}}}{\sqrt{(mg) - \sqrt{(R_1)v_1}}} \right] \dots (3).$$

For the time, T_1 , from the surface to the bottom of the lake, $R=R_2$, and the limits of v are v_1 and v_2 .

$$\therefore T_2 = \frac{1}{2} \sqrt{\frac{m}{gR_2}} \log \left[\frac{[\sqrt{(mg) + \sqrt{(R_2)v_2}}][\sqrt{(mg) - \sqrt{(R_2)v_1}}]}{[\sqrt{(mg) - \sqrt{(R_2)v_2}}][\sqrt{(mg) + \sqrt{(R_2)v_1}}]} \right] \dots (4).$$

$$\text{From (2), } x = m \int \frac{v dv}{mg - Rv^2}.$$

Between the limits v and V we get for x ,

$$x = \frac{m}{2R} \log \left[\frac{mg - RV^2}{mg - Rv^2} \right].$$

$$\therefore v^2 = \frac{mg}{R} (1 - e^{-(2Rx/m)}) + V^2 e^{-(2Rx/m)}.$$

For the velocity at the surface of the lake, $R=R_1$, $V=0$, $x=h$, $v=v_1$.

$$\therefore v_1^2 = \frac{mg}{R_1} (1 - e^{-(2h/m)}) \dots (5).$$

For velocity at bottom of lake, $x=l$, $V=v_1$, $R=R_2$, $v=v_2$.

$$\therefore v_2^2 = \frac{mg}{R_2} (1 - e^{-(2l/m)}) + v_1^2 e^{-(2l/m)} \dots (6).$$

Following Rankin: $R_1 v^2 = \frac{kAe_1 v^2}{2g}$, $R_2 v^2 = \frac{kAe_2 v^2}{2g}$.

$$\therefore R_1 = \frac{0.51 \pi r^2 g \delta}{2g} = .0000008; \quad R_2 = \frac{0.51 \pi r^2 g}{2g} = .000618.$$

Since $h=500$, $l=40$, we get: from (5), $v_1=162.447$ feet; from (6), $v_2=10.0564$ feet; from (3), $T=5.814$ seconds; from (4), $T_1=1.773$ seconds.

$T+T_1=7.587$ seconds=total time. These results would be slightly changed for different values of R_1 , R_2 .

NUMBER THEORY AND DIOPHANTINE ANALYSIS.

NOTE ON PROBLEM 152.

On referring to the memorandum book from which the problem was taken, I find that p is prime, for which case the theorem would appear to be true. PROPOSER.

155. Proposed by R. D. CARMICHAEL, Anniston, Ala.

If p and q are primes and m and n are any integers, find the cases in which the equation $p^m - q^n = 1$ may be satisfied.

Solution by the PROPOSER.

Some values, found by inspection, are given by Zerr in the MONTHLY for December, 1908. A complete solution may be effected by aid of the following lemma (see *Annals of Mathematics*, Vol. 8, No. 4, p. 15).

If x is a positive integer >1 , $x^t - 1$ has a prime factor not dividing $x^u - 1$ ($u < t$), except in the cases $t=2$, $x=2^v - 1$, $v \geq 2$; $t=6$, $x=2$. Such prime